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Final Technical Report

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The Three-Dimensional Structure of the Infrared Cirrus

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This project was carried out over a period of four years, beginning 6/15/89 and continuing through 9/15/93. Intermediate results have been reported as poster papers at several meetings of the American Astronomical Society (Offenberg et al. 1989, Gaustad et al. 1990, Gaustad et al. 1991). A brief summary was presented in April 1993 at a symposium on the infrared cirrus (Van Buren and Gaustad 1994). The final results were published in late 1993 (Gaustad and Van Buren 1993). The measurements have been deposited in NASA's Astronomical Data Center.

Briefly, the results are as follows: Using the IRAS data base, we surveyed the 1808 O6-B9.5 stars in the Bright Star Catalog for extended excess emission at 60 μm, indicating the presence of heated dust (cirrus hotspots) at the location of the star. Measurements of the angular size and infrared flux at 12, 25, 60 and 100 μm were obtained for 302 objects. From these basic data we calculated the radius, absorption optical depth, color temperature, and dust density for each object. Arguing that the stars are randomly distributed point probes of the ISM, we showed that the filling factor of the dust-bearing component of the ISM is 14.6 ± 2.4 % within 400 pc of the sun for clouds with an equivalent hydrogen density greater than 0.5 cm^{-3}. Above a density of 1.0 cm^{-3} the density distribution function appears to follow a power law of index -1.25. Further, we showed that the dust is distributed more sparsely in a region near the sun about 60 pc wide and extending several hundred parsecs in the direction of longitudes 80°-260°. The distances to the dust clouds were determined from the spectroscopic parallaxes of the embedded stars; when the HIPPARCOS parallaxes become available, we will be able to produce a more accurate three-dimensional view of the local ISM.

In the proposal submitted to NASA in 1988, we emphasized the contribution of this work to the education of undergraduate students. In the four year life of the project, 16 students (14 undergraduate, 2 high school) participated. Of the undergraduates, 11 were from Swarthmore College and 3 from other small colleges, members of the Keck Northeast Astronomy Consortium, who worked a summer at Swarthmore as part of an exchange program. Although many of these students participated only as trained measurers, they learned the discipline required of a scientific experiment, and were exposed to the field of infrared space astronomy and the techniques of image processing. Others, particularly some of those who worked an entire summer, became more heavily involved in programming and/or analysis of the data. Six

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attended meetings of the American Astronomical Society, for which they prepared and presented poster papers describing preliminary results, an experience obviously highly beneficial in the development of their scientific acumen and understanding of the workings of the profession. It is not expected, of course, that all of these students will become professional astronomers. Of the 16 participants, 5 are now graduate students in astronomy, 1 is a graduate student in oceanography, 2 are still undergraduate astronomy majors, 3 are majoring in other scientific fields, 1 is a high school science teacher, 1 works for a NASA contractor, and 3 are in non-science areas of work or study.

Two students used the project data for their senior thesis research projects. Andrew Afflerbach '91 undertook to model the infrared flux which would be seen by IRAS from a uniform density dust cloud surrounding a hot star. A program originally written by Daniel Ziskin to calculate the equilibrium temperature and emission of dust grains in such as cloud was modified to include stochastic heating of very small grains. He found that inclusion of the very small grains makes a significant difference in the results, bringing the predicted fluxes much closer to those observed (Afflerbach 1991). In his project Knut Olsen '92 measured the infrared flux in the four IRAS bands at the positions of 150 O and B stars in a region where he also had data on 21-cm emission from atomic hydrogen. He derived the gas density at the three locations of best overlap of the data sets and obtained consistent results, confirming that the method employing a line-of-sight average (the 21-cm analysis) and one employing a point measurement (the infrared analysis) are equivalent. The results also imply that the gas-to-dust ratio in the interstellar medium is fairly independent of position.

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